In the case of a MIMO radio communication system, radio channel coefficient determination with the aid of channel estimation is very complex. With a number M_{TX} of transmit antennae and a number M_{RX} of receive antennae, a total of M_{RX} x M_{TX} radio channel coefficients to be estimated therefore results for M_{RX} x M_{TX} radio transmission channels. Specifically, for a MIMO radio communication system with four transmit and four receive antennae, a total of 16 radio transmission channels results described by 16 radio channel coefficients.

In the case of an FDD (Frequency Division Duplex) radio communication system in particular, precise estimation of the radio channel coefficients requires long training sequences, which in turn take up a considerable number of radio transmission resources.

Transmitter-side pre-filtering of symbols to be sent is known from "Performance Analysis of MIMO Maximum Likelihood Receivers with Channel Correlation, Colored Gaussian Noise, and Linear Prefiltering", Mario Kiessling et al., ICC 2003, IEEE International Conference on Communications, vol. 5, 11.05.2003 - 15.05.2003, pages 3026 to 3030, XP002270467, USA. The described pre-filtering allows improved receipt of the symbols to be achieved in respect of the bit error rate BER and in respect of the signal to noise ratio SNR, with pre-filtering taking place on the basis of statistical algorithms.

Transmit-side pre-filtering is known from "Statistical Prefiltering for MIMO Systems with Linear Receivers in the Presence of Transmit Correlation" Kiessling, 57th IEEE Semi-annual Vehicular Technology Conference, VTC 2003, Jeju, South Korea, vol. 1, 22.04.2003 - 25.04.2003, pages 267 - 271,

XP002270468, for the dimensioning of which there is no need for a precise knowledge of channel state information CSI.

Pre-filtering is carried out based on statistical values.

Further pre-filtering based on statistical values is known from "Statistical Prefiltering for MMSE and ML Receivers with Correlated MIMO Channels", Kiessling, WCNC 2003, IEEE Wireless Communications and Networking Conference Record, New Orleans, LA, USA, 16-20.03.2003, vol. 2, pages 919 - 924, XP002270469.

The object of the invention is to implement an estimation of radio channel coefficients involving little outlay and with greater precision in a radio communication system, in particular in a MIMO radio communication system.

The object of the invention is achieved by the features of claim 1. Advantageous developments are set out in the subclaims.

The claimed pre-filter is arranged on the transmit side before an antenna arrangement such that training sequences are fed via the pre-filter to antenna systems in the antenna arrangement for emission. Channel estimation takes place based on the training sequences to determine radio transmission channel characteristics, which are described by spatial correlations. The pre-filter is dimensioned as a function of the spatial correlations such that a predefined error value of an algorithm used on the receive side for channel estimation is achieved.

Claims

1. Method for pre-filtering training sequences in a radio communication system, in which an antenna arrangement comprising a number of antenna systems is used on the transmit side at least,
   - in which the training sequences are fed via a pre-filter to the transmit-side antenna systems for emission,
   - in which received training sequences are used to carry out a channel estimation of radio transmission characteristics, which are described by spatial correlations,
   - in which to improve the channel estimation carried out with the aid of the training sequences, the training sequences are adjusted by the pre-filter to the radio transmission channel characteristics, with
   - the pre-filter being dimensioned as a function of the spatial correlations to achieve a predefined error value of an algorithm used for channel estimation.

2. Method according to claim 1, in which the receive-side error value is predefined as a minimum value for a predefined training sequence length or in which the predefined error value is achieved by adjusting the length of the training sequences.

3. Method according to one of the preceding claims, in which an MSE algorithm is used for channel estimation on the receive side.

4. Method according to one of the preceding claims, in which a beam forming method is implemented by the pre-filter for every training sequence, in that the pre-filter assigns both a power and an antenna system to the training sequence.

5. Method according to one of the preceding claims, in which the training sequences are pre-filtered based on the following equation:

$$F \cdot S = V_{Tx}^{*}\Phi_f S$$

where:

S is the transmit-side training sequence matrix,

F is the transmit-side pre-filter matrix,

V_{Tx} is the eigenvectors of a transmit-side correlation matrix with long-term stability with transmit-side radio channel coefficients and

Φ_f is the diagonal matrix for power assignment.

6. Method according to claim 5, in which the diagonal matrix Φ_f is formed taking into account an MSE error value ε based on the following formula:

$$\varepsilon = tr(\Lambda_{Tx}^{-1} \otimes \Lambda_{Rx}^{-1} + \frac{N_t}{N_0}(\Phi_f \Phi_f^H \otimes I))^{-1}$$

where

N_t is the training sequence length,

N_0 is the noise power,

I is the unit matrix,

Λ_{Rx} is the eigenvalues of a receive-side correlation matrix with long-term stability with receive-side radio channel coefficients,

Λ_{Tx} is the eigenvalues of the transmit-side correlation matrix with long-term stability with transmit-side radio channel coefficients.

7. Method according to claim 5 or 6, in which the MSE error value ε is minimized for a transmit-side and receive-side correlation of radio transmission channels or antenna systems in respect of the diagonal matrix Φ_f based on the following formula:

$$\underbrace{\min}_{\Phi_f} tr\left(\Lambda_{Tx}^{-1} \otimes \Lambda_{Rx}^{-1} + \frac{N_t}{N_0}\left(\Phi_f \Phi_f^H \otimes I\right)\right)^{-1}$$

with a power restriction being defined as a secondary condition based on the following formula:

$$\rho = \sum_{l=0}^{M_{Tx}} \Phi_{f,l}^2$$

8. Method according to claim 5 or 6, in which the following applies for a transmit-side correlation of radio

transmission channels or antenna systems for elements of the diagonal matrix Φ_f:

$$\Phi_{f,l} = \left[\frac{1}{M_{Tx}} \left(\left(\frac{N_t}{N_0} \right)^{-1} tr(\Lambda_{Tx}^{-1}) + \rho \right) \cdot I - \left(\frac{N_t}{N_0} \right)^{-1} \Lambda_{Tx}^{-1} \right]^{0,5}$$

with the secondary condition $\Phi_{f,l} \geq 0$.

9. Transmit station and/or receive station of a radio communication system with means, which are embodied to implement the method according to one of claims 1 to 8.